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Agro-energy districts contributing to environmental and social sustainability in rural areas: Evaluation of a local public–private partnership scheme in Greece

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ABSTRACT

The current economic downturn has put public budgets under pressure, reducing investments and revenues for local stakeholders to cope, among other things, with contemporary demands of environmental protection. Local-based partnerships may provide an efficient tool by adopting, integrating and implementing actions based on awareness and participation of a set of different players. This need is even more evident in rural areas in which a proposed decentralized bio-energy production model established in Agro-energy districtscan provide incentive and create a comfortable ground for the development of an energy production plant based on a mixed public-private partnership. Drawing on the implementation of a European co-funded research project the paper presents the efforts being made to build a partnership at a local level in order to cover the lack of an institutional plan and public investment for handling biomass production. Our aim is not primarily to present the best technical solution to bio-energy production but rather to illustrate the networking between different players, the public consultation, and the agreements being made under the form of Public Private Partnerships, as well as the levels of commitment and the risks taken. The gist of this study is that despite the civic engagements the inconsistent administrative environment, the dominance of the public sector and the State intervention through legislation and different political decisions, makes it still difficult for local partnerships to exercise their power and turn from government to governance in order to cope with the environmental challenges and tackle inequalities faced in rural areas.

Contents

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1. Introduction

Mitigating climate change effects is one of the cutting edge problems currently at a global level. Replacing fossil fuels with biofuels and therefore reducing greenhouse gas emissions are some of the contemporary environmental drivers for taking actions both local and global level. Within the framework of a European Energy Policy [1] the EU intends to create a high efficiency energy economy with low CO_2 emissions; in so doing, it has set several important energy objectives some of which are closely related to rural areas.

Whereas agriculture is accused[1] of being one of the most important sources of global greenhouse gas emissions [2], it can also play an important role in meeting several environmental objectives for the EU. According to Best [3] “agricultural and livestock resources are abundant in most parts of the world, and various commercially available conversion technologies could transform current traditional and low-tech uses of these resources to modern energies”. Therefore, new action at a local level must be taken and according to the proposals for the EU Rural development-after 2013, farming and other rural sectors could supply essential raw materials, for use in the bio-economy (from wastes, residues, non-food raw materials etc). Especially under the new reform of Common Agricultural Policy (CAP) new challenges (following the CAP health check of 2008) have to be met, amongst which renewable energies and especially agro-energies[2] hold a major position; under the condition that food production will not be compromised [4]. Agro-Energy produced in a sustainable manner is considered to have better results, compared to fossil fuels. The most promising ones are considered to be food security, rural development, local self-reliance, sustainable agricultural management, biodiversity, conservation and climate change mitigation [3]. Hosting one or more agro-energy chains, technologically, organizationally and economically tailored to the production and use of energy from agriculture, normally through (but not necessarily limited to) the use of the local and regional biomass supply can provide local solutions.

Nevertheless, this is not always an easy task. The current economic downturn in Europe and in Greece specifically, has put public budgets under pressure. This situation led to reduction in public investments and lack of sources of revenues for local-regional authorities in order to cope, among other things, with contemporary demands of environmental and social sustainability. The situation is even difficult in rural areas due to their diversity, inherent structural problems, inequalities and geographical handicaps. These difficulties posed by economic restructuring, and enhanced in marginalized rural areas, will be possibly dealt better by building trustworthy relationships [5] and local-based initiatives and partnerships. The latter may provide a viable scheme in order to achieve environmental goals and offer public services in an efficient manner by adopting, integrating and implementing actions based on local awareness and participation. In fact, partnerships of different set of local players with power differentials but high levels of trust amongst them; in which the boundaries between the public and private sectors become ‘blurred’ [6], have become central to contemporary rural governance [7] by providing new solutions to problems faced by rural areas throughout the developed world [8].

Towards this direction, Mangoyana and Smith [9] argue that the mixed Public Private Partnership (PPP) is an emerging tool particularly in times of economic crisis, during which public budget are cut down and public bodies cannot provide with services and infrastructure local communities. Even though there are still constraints in the application of PPPs in bio-energy, there is a growing tendency to take actions in the field of renewable energy making agreements between public and private enterprises [10]. During the development of a bio-energy project risk assessment regards different aspects: plant reliability, plant economics, plant guarantees, contract, warranties, etc. Papers describing risks and or threats in bioenergy chains are [11,12]. From these papers it can be inferred that PPPs are able to decrease: authorization risks, financing risks, biomass contracting risks.

In fact within territorial districts a set of agro-energy chains could interact and develop synergies lowering production costs.

An example of synergy among bioenergy chains is represented by the coupling of a pyrolysis/gasification plant to a biodiesel or bioethanol production plant [13–16]. In those cases electricity and heat required for biodiesel/bioethanol production can be provided by biomass CHP, lowering production costs. Obviously to build up those synergies investments are required, but the positive effects of PPPs on the economical sustainability of bioenergy projects are due to 2 main aspects: sourcing of finance and cost reduction [17]. Cost reduction in a PPP project can be done through synergies as explained above but also reducing project authorization costs (that can be even about 7% of project investment budget [18]).

Drawing on the implementation of a European co-funded research project this paper set out to explore the application of a PPP scheme to Agro-energy districts (AeDs). In so doing, it acknowledges the importance of the AeDs that represent a useful model for the achievement of environmental goals for Europe. Our interest will focus on a proposed PPP scheme for the case of a rural area in Northern Greece [19–22]. The paper starts by presenting the rationale behind PPPs for AeDs. Onwards, presents the efforts being made to build a partnership at a local level in order to cover the lack of an institutional plan and public investment for handling biomass production. Whereas finding the best technical solution to bio-energy production for decreasing operating costs is one of the most important problems facing biofuels implementation this paper tries also to illustrate another major issue, that is the networking between different players, the public consultation, and the agreements being made (or not) under the form of PPPs, as well the levels of commitment and the risks taken (or not).

Know-how on biomass to energy technologies has reached a good level [23]; plant simulation is improving providing more accurate information on plant performances [24,25], process simulation is always more detailed through the use of new methods and improved instrumentation (such as TGA [26]), there are available on Literature low-cost methods for the reduction of pyrolysis/gasification tar in producer gas [27]. The choice of the best technology is an optimization problem that has been taken into account in other papers published in Literature (for example consider [28]).

This paper takes into account the administrative, legal, financial agreements that regulate a bioenergy project in practice, once that

[1] Despite the fact that agricultural emissions for 27 EU countries actually fell by 20% between 1990 and 2006, farming still represents 9% of the EUs greenhouse gas emissions [2].

[2] Refers to the energy function of agriculture and it can make significant contributions to achieving social and environmental sustainability at local, national, regional and global levels. The agro-energy sector concerns in particular the use of biomass which corresponds to all plant matter, irrespective of whether it is obtained from natural, forestry or agricultural sources [http://www-re.wu.ac.at/ersa/ersaconfs/ersa11/e110830aFinal00318.pdf].

the technological problem has been solved. In particular focusing on PPP type of contract. Discussion is also drawn upon results of focus-group interviews with all members of the project's Consortium as well as local population, entrepreneurs and farmers. Qualitative methods have been used in addition to quantitative ones due to the fact that they can contribute to fundamental theory and knowledge by providing access to data and insights otherwise not apparent. Towards this direction, some of the basic questions raised are: if in fact an engaged society can overcome the lack of an institutional framework; if there can be found a good balance between all partners involved in order to efficiently tackle the inequalities and environmental challenges faced in the area. Such a participation in associational activities is seen as a key indication of socially healthy, engaged society [29] hence, in terms of strategic impact; the paper aims to facilitate the organization of the entire bio-energy chain for not only environmental but also social sustainability in rural areas [30,31].

2. The rationale of PPPs for Agro-Energy Districts

A proposed useful model could be the establishment of Agro-Energy Districts (AeD) in rural areas; whereas territorialized, has the possibility to overcome its limited geographical borders for the supply of materials, ensuring the continuous supply of materials for energy production, allowing thus the AeD to be a reliable contractor with third parties for the supply of energy from the district. However, the main policy driver of the AeD should be the capability to use internal resources for the production of energy to be used both internally and externally (for commercial purposes). Hence there comes the question of taking action at a local level and trying to find ways to cope and decide upon the best development trajectory for the rural area.

Dealing with an AeD four main possible directions can be chosen: auto-producing energy, selling heat, selling power, selling heat and power. Besides this, other classification of biomass business can be made depending on the property of biomass plant, or of the biomass itself (private property, public property, public-private shared). According to the aforementioned four models of partnerships can emerge. One can be producing heat (for the public) and/or power with public or private biomass using concession PPP model. Auto producing heat with public or private biomass and/or selling electricity to the grid is also one of the models. Finally, other can be selling heat to privates and possible selling power to the grid and private plant selling power to the public.

Which model of partnership will be chosen depends on several aspects. Changes and reallocations in the national and EU budget underline the necessity of increased engagement of private funds. The Member States have different levels of experience and legislation, but the general tendency is towards the increased importance of PPPs [32]. Nevertheless, a constellation of drawbacks (regulatory, financial and awareness lack) has not yet allowed a wide proliferation of the concept of PPPs to agro-energy.

Governments are encouraged to adopt PPPs as a tool for sustainable development. Investors in PPPs have a financial motivation for taking environmental considerations into account, due to the fact that the effective use of resources and reduction of waste both in design and construction, may contribute to lowered whole life costs, and hence higher margins. Citizens, from their point of view, demand more attention from their governments to the social and environmental impact of such projects [33].

The theory behind PPPs recognizes that both parties have certain advantages relative to the other in the performance of specific tasks. By allowing each sector to do what it does best, public services-goods and infrastructure can be provided in the most economically efficient manner [34]. The overall aim of PPPs is therefore to structure the relationship between the parties, so that risks are borne by those best able to control them and increased value is achieved through the exploitation of private sector skills and competencies [35].

The objective of PPPs is to involve private partners in the implementation of projects or the provision of services, aiming not only at securing additional financial resources, but also at benefiting from their know-how, human resources, innovative approach and ability to efficiently manage complex projects for the public benefit. Amongst the main benefits of PPPs is also the ability to finance more projects and the risk transfer to the private sector seems to be the most common ones [36].

The Power Purchase Agreement (PPA), developed in the United States in the 1980s, provided the template for modern PPP Contracts. PPAs began after the 1978 Private Utility Regulatory Policy Act (PURPA), which encouraged the construction of cogeneration plants, whose electricity could be sold to the regulated power utilities [37]. PPAs arrived in Europe in the early 1990s, with the privatization of the British electricity industry; this encouraged the separation between private-sector companies involved in power generation and those involved in distribution, and the development of independent power projects to increase competition in power generation. The PPA as first developed was a 'Build-Own-Operate' (BOO) contract between private-sector parties, whereby the ownership of the power station remains with its investors [37].

Many international organizations, like the Asian Development Bank [38], seek to forge strong internal PPPs in the countries in which they operate, as they have tested that such partnerships provide a valuable bridge between the two sectors. The problems in PPPs in developing countries are quite different than the ones raised in Europe. For example, many international companies are unwilling to expose themselves to capricious regulatory frameworks and changing government policies [38]. On the other hand, in the USA for example, PPPs are not very common, even though energy issues seem to get PPPs moving. International experience suggests that the quality of service achieved under a PPP is often better than that achieved by traditional procurement. This may reflect the better integration of services with supporting assets, improved economies of scale, the introduction of innovation in service delivery, or the performance incentives and penalties typically included within a PPP contract [35].

In the PPP process a set of different stakeholders (with different power claims) can exist. According to Asian Development Bank [38] governments, consumers, employees and investors build a diverse range with emerging difficulties in reconciling interests and concerns. They all have to play a role in the partnership and participate in a broad consultation or communication with each other in an attempt to minimize conflicts, which in turn might delay the project.

In Greece, the implementation of PPP is described by the Greek National Law 3389/2005 [39], which provides the legal framework for all types of PPPs. In regards to RES only recently the Greek Law 3851/2010[3] simplified the licensing procedure trying to cope with the need to fulfill the 2020 goals [40] and integrate RES. It offers a fixed guaranteed price of 0.23 cents/KW for biomass utilization plants that established without public subsidies. This price is reduced to of 0.20 cents/KW if public subsidies are utilized for the establishment of the plant. The price is guaranteed for 20 years for operation that start after 2011 and until new price is set.

[3] "Accelerating the development of Renewable Energy Sources (RES) to deal with climate change and other regulations addressing issues under the authority of the Ministry of Environment, Energy and Climate Change".

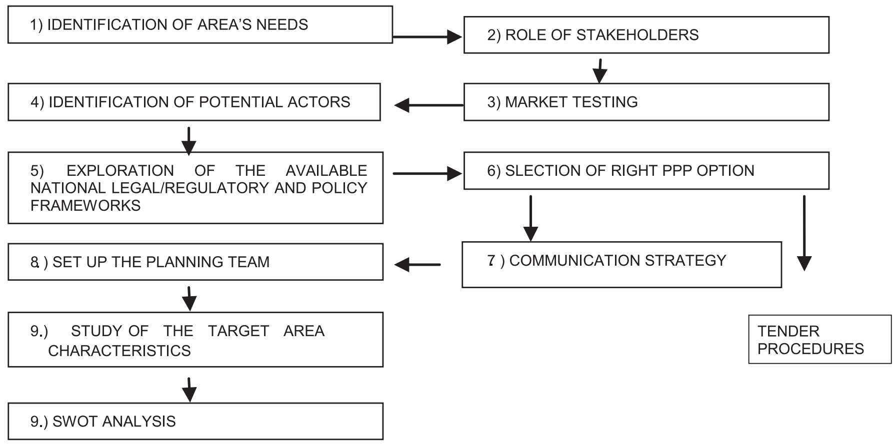


Fig. 1. Implementation of the methodology: preliminary actions.

Within the aforementioned legal framework, Greek municipalities are better organized towards taking action in the field of the renewable energies, making agreements with private enterprises, creating awareness to the citizens of the benefits related to renewable energies, involving town and citizen associations into common projects, cooperating with industrial associations and technology institutes for feasibility studies, trainings, and strategy decisions. According to Panoutsou [41] in 2006 bioenergy accounted for 61% of renewable energy sources in Greece. Besides Boukis and others [42] state that biomass could play an important role in achieving the target of 20% electricity production from RES in Greece. There are already some examples of biogas plants [41] run by consortia between private parties and municipalities, therefore the presented project appears to be of fundamental importance to trace the guidelines for PPPs in Greece.

According to Arabatzis [43] the biomass, from both agriculture and forestry, is one of the RES that can help toward meeting the 2020 goals and reduce energy dependency of the country. However, even till today, the general treatment of biomass produced in rural areas in Greece is either to incorporate them into the soil or burn them in the field. A part is already exploited and used in several energy and non-energy markets. For example, cereal straw is used for various purposes such as animal feeding and animal bedding; in some cases also used for heat production in greenhouses. There are no alternative markets for cotton, corn stalks and corncobs but difficulties in harvesting and handling and as far as olive prunings (especially the large stems) they are used in stoves and chimneys for residential heating.

Quite often a renewable energy consortium is created when there is a clear and strong policy will to proceed in Municipalities. The first step is almost always the Mayor's decision supported by his advisers to take part into a renewable energy initiative, and implement changes and improvements into the Municipality district. Afterwards, the appropriate private companies (technology sellers, installers and maintenance) are contacted for a request for tender to next start up the project. Finally, the decrease in the external energy dependency and the deregulation of the energy market of Greece facilitates the selling of electricity produced by an agro-energy plant to the Public Power Corporation and the connection to the PPC network is relatively easy.

3. Methodological framework

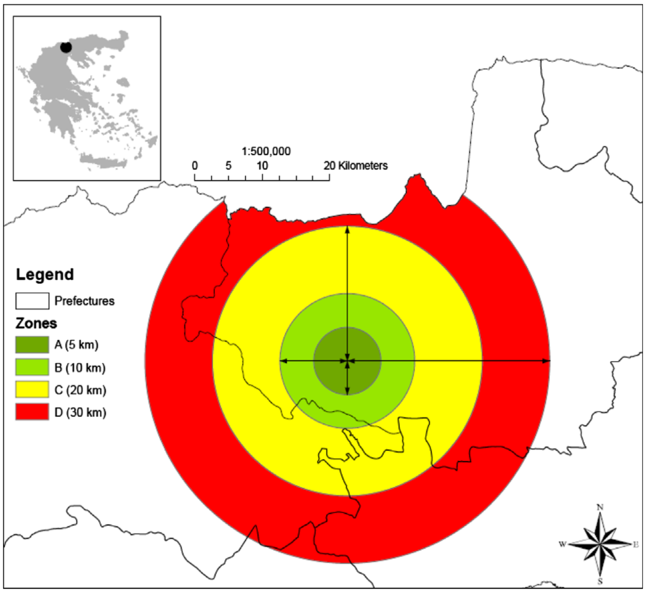
Based on a case study research in a northern part of Greece, a predominantly rural area, this paper focuses on the efforts being made at a local level to implement a PPP on agro-energy. The paper does not focalize on a specific technology for the production of biomass residues, which has been well documented in the literature [44]. According to Boukis et al. [42], a set of possible technologic and economical solutions could apply for the use of biomass but only a strategic and comprehensive vision is able to create a comfortable ground for the creation of an energy production plant managed by a PPP. Depending on local conditions, local needs, and availability of technologies, the study will identify different dimensions of production plant, linking technological development to the market and to public/community needs.

The first step in this study was the identification of the needs of the study area (Fig. 1). A sector analysis was carried out and the technical specifications of the proposed PPP project were defined in order to elaborate to what degree an enabling environment exists for PPP and what activities are required in advance for the creation of such an environment. The diagnostic made was important in order to: (i) identify the strengths and weaknesses of the sector and the most promising area for efficiency increases, (ii) regularly gauge and report on the progress of reform, and (iii) tweak the reform program as needed.

The second step was the preparation stage during which we developed the preliminary technical specifications, an iterative process, which built on feedback from the market and the affordability of the project at each design stage. The technical design started with identification of desired coverage targets and service standards. From these starting points, estimating the cost of these desired services (factoring in presumed efficiency gains) and cost recovery tariffs was made possible.

A third (major) step of public awareness and consultation took part in order to communicate the benefits of the PPPs. Round-table discussion raising the levels of awareness stimulated local community and local stakeholders in a public consultation. This process of involvement and discussion with stakeholders ended with the identification of a commonly agreed scheme of PPP and AeD between all future PPP partners. During this stage, stakeholders have also provided valuable input to the design and practicality of an approach while at the same time their understanding of the reform agenda encouraged them to stay committed.

A pre-feasibility study elaborated the proper combination of elements, able to comply with target area characteristics and needs. This process finalized the main frame of potential partnership amongst local public authorities, agricultural SMEs, associations of entrepreneurs and financial institutions as well. This frame helped to draw up the potential PPP contract scheme as a precondition for the signature of the Memoranda of



Map 1. Zones of influence for biomass production exploitation at 5, 10, 20 and 30 km radius from Toumpa Kilkis.

Understanding by all interested partners. Finally, with the use of key-informants and focus group discussions, qualitative survey (questionnaire) as well as participatory observation we elaborated most of our research questions.

4. Study area description and biomass production

The selected study area was the Kilkis Prefecture, located in the northernmost point of Greece. It includes 11 Municipalities and one independent community and covers an area of 2519 km^2, with 86.086 inhabitants [45]. The Prefecture of Kilkis has an agriculture-based economy with 45% of the active population involved in the primary sector of economy in which, according to Eurostat [46] the total agricultural area is 116,510 ha. The Prefecture plunges to the last ranking the development indicators (GDP etc.) and has been also included in the list of Greek areas with high risk of desertification due to intensive agriculture and soil degradation [47].

The Kilkis prefecture was selected as the study area for three reasons; (1) the existence of sufficient agricultural residues from annual and perennial crops for biomass production, (2) the Tobacco Cooperative of Toumpa Kilkis, a main partner of the European project RuralE-Evolution is located in this prefecture, (3) local farmers, municipalities and enterprises had showed a great interest in agro-energy PPP.

The scenario developed for the study area was the use of the agricultural residues from plants of members of a Local Agricultural Co-operative (seeds or shells or both) for the production of energy that could potentially be used for the needs of the Cooperative and the local energy needs of the local Municipality, while selling the excessive energy produced to the national grid. All figures measured for the description of the study area consider the village of Toumba where the agricultural Co-operative is located. According to this target area characteristics for biomass production exploitation and other figures were measured and presented in the following section and Appendix.

4.1. Biomass production and exploitation in the study area

Agricultural land was computed at 1907.8 km^2 using Corine Land Cover. The net agricultural area was computed by neglecting pastures (5460.7 ha according to corine) and a 40% of the remaining land, which was attributed to roads and buffer zones (it was determined using sampling sites using orthophotos). The net agricultural land distributed in four zones (Map 1) correspond to a radius of 5, 10, 20, and 30 km from the point of construction of the biomass utilization plant in Toumba village (see also Table A1 Appendix A).

Onwards, according to published literature referred to Greek and Italian conditions [48,49] the crop distribution for each exploitation zone is presented in Table B1 (Appendix B) and the type and the yield (t/ha) of residues in Table B2 (Appendix B). Using the data from these two tables we determined the biomass production (tones) per zone and per crop. This came up to a total 188,540.1 tons (Table B3 Appendix B).

4.2. Determine heat and electricity production in the study area

Using the LHV values [47,48] for each crop, heat and electricity production using biomass was also determined using the following equations (Tables B4 and B5 Appendix B), respectively:

$$\textit{Heat production}\ (\mathrm{MJ}) = 0.9\textit{Biomass}(\mathrm{kg}) \times \mathrm{LHV}(\mathrm{MJ/kg})$$

Assuming that the boiler efficiency is 90% (1)

$$\text{Electricity production (MJ)} = 0.2 \text{ Biomass (kg)} \times \text{LHV (MJ/kg)}$$

Assuming that the power plant efficiency is 20% (2)

Heat and electricity production (MJ) was transformed to MWh using the following transformation 1 MJ = 0.0002778 MWh (Tables B6 and B7 Appendix B). Considering that thermal power is distributed for 2000 h per year of operating time, and electrical power for 7000 h per year of operating time, the conversion to MW power production was performed in Tables B8 and B9 (Appendix B) respectively.

The results of these aforementioned calculations show a high biomass availability from residues (agricultural, agro-forest residues) due to the extensive agricultural land. Additionally, zootechnical and food industry residues can also be collected. Interviews with farmers revealed also that it can be easily collected as the majority of them want to *"get rid of the residues from the fields"* [*as quoted by many farmers*]. Nevertheless, apart from the strengths in the area some weaknesses have been also noted during the field research.

First of all, following the country's overall profile with a myriad of small and scattered agricultural holdings, the agricultural land in the study area is divided in small parts, which make the harvesting and transportation cost higher. On field research showed also that there are too many different land owners (farmers), which cannot be reached. A point also argued for the area in which some of farm heads were found to be 'absent' from the land and only farm-heads 'on paper' and not in reality [50].

Finally, in regards to the area some other issues emerged. Such as the necessity to improve or even expand in cases the obsolete road infrastructure. Furthermore, many farmers quoted that *"there is an opportunity cost of the residue for example the cereals straw has already a market price as it is sold for animal feeding purposes"*. Whereas others posed the lack of commercial harvesting machinery for certain residue types (e.g. cotton residues) and the lack of safe biomass supply in long term.

5. The proposed PPP and the role of the local stakeholders

The proposed PPP scheme in the area involved two main parties; that is the Public Body (the Municipality of Evropos), that will be the user of the energy (heat/electricity) produced and the

Tobacco Cooperative of Toumpa Kilkis (TCTK) which will be furnishing the biomass. According to the key-informants TCTK is the longest-lived tobacco co-operative in the country, it was established during 1983, in order to organize and trade its members' production of eastern type tobacco. In 1987, they moved on to full reconversion of the tobacco growing by replacing the Kaba Kulak (classic) variety with the Virginia variety. At the same time, they created and operated a unit of 180 dryers under the supervision of the Co-operative's technical personnel. In 2005, the co-operative consisted of 180 members, with 4.500 quarter acres tobacco growing and a production of 1.348.000 kg of Virginia variety tobacco.

However, following the adoption of total decoupling for the tobacco sector in Greece, production fell by 80%. In fact, during 2006, with the application of the new CAP, almost all its members abandoned the Virginia tobacco growing and turned to the search of alternative crops. Today the Co-operative consists of 80 members. Concerning employment, existing estimates suggest that the number of permanent employees has reduced by 50%, whilst the number of seasonal workers has been reduced from pre-reform levels of 7000 to about 2000.

Aiming to expand its members' plantations with high quality saplings at reasonable prices, the Co-operative was immediately engaged in other crops. In this context and evaluating the trends of the European and global market, they have initiated the plantation of pomegranate trees. At the same time, and targeting the product's powerful and flexible access to the market, under the initiative of some venturesome young members; identified as members of new coalitions for knowledge diffusion and innovation [51], they have created the company “Rodonas” Ltd. Today, over 150 producers, with over 2000 quarter acres pomegranate trees around the country are contracted. The production of pomegranate fruits in 2008 reached 4000–8000 t and there are plans to increase the cultivated hectares within the next years and plant even more different kind of trees. This choice was seen as an opportunity to maintain farmers' jobs and create a competitive rural economy that will be independent from subsidies and will eventually lead to sustainable agriculture and sustainable development of the rural area.

The PPP concept considers the use of biomass residues from this plant (such as seeds and peels) as well as the use of biomass residues from the adjacent areas cultivations for the production of energy. There seems to be a great potential for the use of the field crop residues and it was estimated of having 2000 t of dry material, with 19,000 KJ/kg LHV. The energy conversion plant will be owned by Rodonas Ltd and by the local agricultural cooperative.

At this point we must note that the Public Body involved was the Municipality of Evropos located in the Paionia Province of Kilkis Prefecture. Fig. 2e elaborates the relations between the different stakeholders (public and private ones) for energy production in the study area. Besides the above entities, the concerned parties agreed to network and integrate other actors such as local farmers, SMEs and agricultural cooperatives, local public bodies, banks, credit institutions, SMEs, consumer associations and regional bodies dealing with environmental-energy issues.

After several round table meetings with all potential partners the exact roles of each partner were defined in addition to the proposal to include more potential actors in the PPP scheme. The basic roles were distributed accordingly. Rodonas Ltd. will provide raw material to the plant. The TCTK was set to provide the land and invest in the construction of the plant. Furthermore, it has the obligation to motivate its members for the provision of biomass to the plant. The Municipality of Evropos was decided to use the energy produced from the plant to cover the electricity needs of its buildings whereas other proposed uses by the cooperative were: cool and preserve the fruit and fruit juice produced from pomegranates; and sell the surplus energy to the National Public Power Corporation as energy from biomass residues Fig. 2.

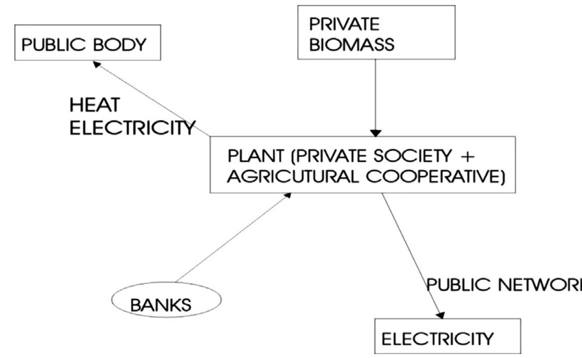


Fig. 2. PPP scheme description for the study area.

Public consultation led to the signing on a Memorandum of Understanding between all actors, clarifying actions for each party and implementation goals. For the purpose of fulfilling their obligations under the signed Memorandum the two main bodies established a Committee, which would undertake the monitoring. The contract type was decided to be the one of Build-Own-Operate.[4]

6. Evaluation of the PPP scheme

Following the results of the questionnaire distributed to the actors involved, some strong and weak points in the implementation of PPPs are argued in this section. The majority of the actors posed the partnership structure as being the most essential issue. Some of the local players involved in the partnership consider the dedication and cooperation (trust) among the parties the most important success factor, together with the value of the concept. When ranking the commitment of the key actors to implement the PPP scheme we observed that Farmers' organizations are most committed, followed by individual farmers and then by the private companies. Local authorities and other SME-s in the area are less dedicated.

The clear vision and the strong will, especially from the principal stakeholders, to proceed was also highlighted; whereas the rest of the partied involved needed to be further stimulated. The local community for example is willing to support the project but only after understanding the benefits and the direct affects both environmental and societal. A point also made in the case of another form of RES [40].

In regards to the main motivations of the implementation results of the content analysis of the interviews highlighted some of the perceived benefits. The environmental benefits were identified as main motivation. Similarly, high ranking motivations are the better utilization of biomass and the alternative income for farmers as well especially during these times of economical crisis this opportunity poses a great interest. The general economic advantages and job creation are an important but less determinable motivation, according to their answers. The decrease in external energy dependency, which can be a main object of AeD, was also checked.

The fear of the unbalanced risks amongst partners and the unbalanced financial power was presumable, because local authorities, due to their attributes, have less financial and more political forces and the private partners are in the opposite position.

[4] The BOO contract applies in the case of a PPP where ownership of the facility does not revert to the public authority after the end of the contract [22].

The changes in the economic situation and/or in the legal frame (including the governmental incentives as well) represent similarly high level of risk to the actors a point also made in other research regarding a local sympraxis for environmental action [52].

Amongst the risk factors, fear from the unsafe supply has also to be mentioned, typically in such cases when the farmers' motivation and awareness is low. At the same time, this risk generally exists where the financial institutes are not well prepared to the PPP, or the general economic conditions are unfavorable to PPP. Many have proposed a strong insurance policy for the private actor and a risk mitigation plan in order to have profit assurance for the private sector.

The planned project finally was highly related to the political situation in Greece and the determinable role of local authorities as public partners. Due to the late reform (implemented onwards January 2011) of the Greek Regional Administration and Local Government there has been a change in the distribution of the country's municipalities and the administrative Charta on Greece. The reforming and merging of municipalities and responsibilities has changed all legislative framework at this point*"no one knows exactly who does what and by what means"* [as quoted].

Finally, the very bad economic situation that characterizes almost all Greek municipalities has as a consequence many important operational and organizational difficulties that were not identified from the beginning that add to the drawbacks for a successful implementation of the PPP.

7. Conclusions

Energy PPPs make extensive use of local resources, leading to price reduction of the offered public goods, improvement of living standards and sustainable development especially of rural areas [53,54]. However, Greece has just started to introduce legislative reforms and guidelines in order to provide local solutions to several environmental threats. Unfortunately, this regulatory, financial and awareness lack, are constraints that do not allow a wide proliferation of the concept of PPPs to AeDs.

Main concerns include also development priorities, environmental impacts, land use conflict (energy crops over food crops), technological conversion efficiency, high raw material costs and the cost-effectiveness of Agro-Energy technologies. In economic terms, incentives might be necessary at least to put Agro-Energy on a more equal footing with fossil fuels, for which environmental and social costs are not internalized.

The allocation of design and construction responsibility to the private sector, combined with payments linked to the availability of a service, provides significant incentives for the private sector to deliver capital projects within shorter construction time frames. PPP projects, which require operational and maintenance service provision provide the private sector with strong incentives to minimize costs over the whole life of a project, something that is inherently difficult to achieve within the constraints of traditional public sector budgeting.

The gist of this study is that despite the civic engagements and the produced capacity of trust, reciprocity and co-operation [29] the short-term arrangements (as far as the project's duration) cannot provide a long-term solution which is needed in order to achieve sustainable development [55] and macroeconomic benefits from the utilization of biomass residues [56]. The inconsistent administrative environment, the dominance of the public sector and the State intervention through legislation and different political decisions, makes it still difficult for local partnerships to exercise their power and turn from government to governance [57] in order to cope with the environmental challenges and tackle inequalities faced in the rural area.

Although the present study focuses to the preparation activity of PPP, the final output (contract amongst partners) requires considering and applying the principles of good governance in PPPs. It means that during the adaptation of prefeasibility analysis and preparing the contract, it has to be found a good balance amongst potential stakeholders, optimal technical solutions and such financial solution, which provides sources both to the construction and to the sustainable operation of investment.

The methodology to build and organize a PPP has been described with the help of a case study tailored on Kilkis prefecture. The cultivated area has been analyzed using GIS data. Agricultural surface represents the 72.71% of the total area and the most cultivated crops are: hard wheat (about 114,521 ha), maize (about 24,903 ha) and cotton (about 22,103 ha). The total thermal power achievable from the total residual biomass is equal to 386 MWt, while the total electrical power achievable is equal to 24 MWe. This estimate is a little higher that that presented by Boukis and others [42] (that is 15 MWe), but this can be explained with the fact that more data were employed in this case and more residues were considered. So the methodology presented in this paper deepens the work done by Boukis and others for all the prefectures, just pointing only on Kilkis territory. Once the characteristics of the area have been analyzed the methodology identifies the right PPP scheme, that in this case is represented by the following project partners: private biomass supplier, banks, public body, Public Power Corporation.

A common issue arising in public discussions on PPP in Greece is that the latter has been a very controversial discussion topic in the debate on the role of public and private bodies in a modern state and some projects might not be protected from political and investment volatility especially amidst the current economic and political environment in the country.

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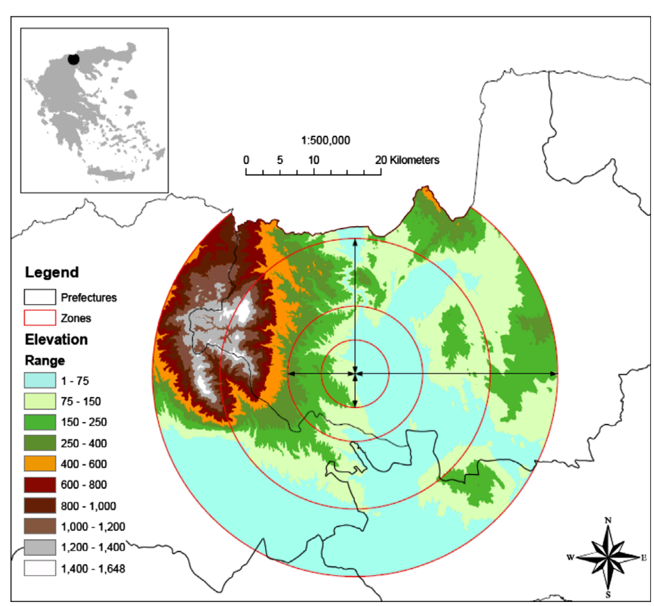

Fig. A.1. Terrain elevation of the study area and zones of influence at 5, 10, 20 and 30 km radius from Toumpa Kilkis.

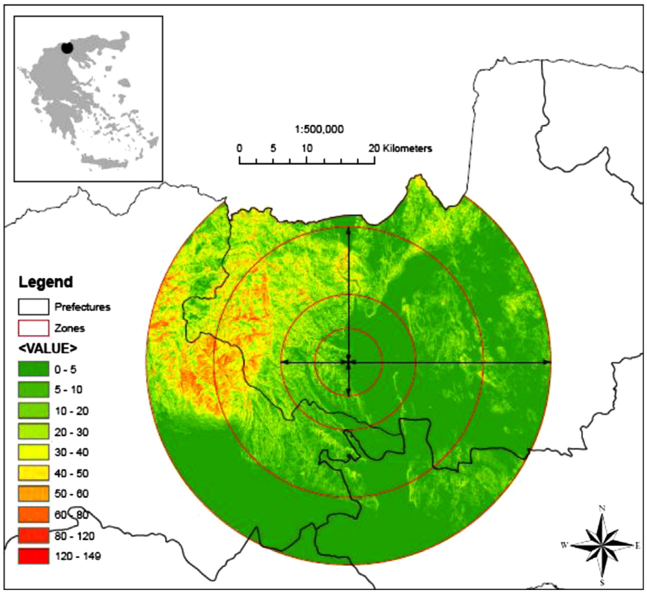

Fig. A.2. Terrain slope % of the study area.

Table A.1
Area coverage for each zone.

Zone	Radius (km)	Area (km^2)	Distribution (%)
A	5	78.5	2.99
B	10	235.6	8.98
C	20	942.5	35.92
D	30	1367.3	52.11
SUM		2623.9	100.00

Table A.2
Land use distribution in the study area.

Type	Area (km^2)	Distribution (%)
Agricultural land	1907.8	72.71
Artificial surfaces	58.7	2.24
Forest and seminatural areas	622.8	23.74
Water bodies – wetlands	34.6	1.32
SUM	2623.9	100.00

Table A.3
Net agricultural land distributed in the four zones.

Zone	Area (ha)	Distribution (%)
A	4313.0	3.9
B	11,806.2	10.6
C	37,186.3	33.4
D	57,884.0	52.1
SUM	111,189.5	100.0

Appendix A. Area characteristics for biomass production exploitation

See Figs. A1 and A2. See Tables A1–A3.

Table B.1
Crop distribution (ha) per zone.

Crop	Zone (area in ha)				SUM
	A	B	C	D	
Pomegranate	163.0	85.3	57.1	29.6	335.0
Cherry trees	54.3	22.7	68.6	142.3	287.9
Vineyards	25.0	71.7	226.8	342.0	665.5
Tobacco	15.8	13.0	68.3	102.9	200.0
Rice	0.0	0.0	0.0	1847.1	1847.1
Sunflower	1.9	5.5	17.4	26.3	51.1
Cotton	331.3	949.2	3004.8	4529.7	8815.1
Hard wheat	3166.1	9067.2	28,704.9	43,268.7	84,207.0
Maize	257.2	736.7	2332.1	3515.7	6841.7
Oat	3.5	10.1	32.1	48.3	94.1
Barley	151.8	435.0	1377.0	2075.8	4039.7
Rye	125.7	360.1	1140.0	1718.6	3344.5
Olives	17.3	49.6	157.2	236.9	461.1
SUM	4313.0	11,806.2	37,186.3	57,884.0	111,189.5

Table B.2
Type and yields of agricultural residues.

Crop	Residue type	Residue yield (wet basis) (t/ha)	Moisture (%)	Residue yield (dry basis) (t/ha)
Pomegranate	Prunning	2	40	1.2
Cherry trees	Prunning	2.5	40	1.5
Vineyards	Sarmenta	2.9	50	1.5
Tobacco	Stems	2.2	85	0.3
Rice	Straw	3.8	25	2.9
Sunflower	Stalks and straw	4	40	2.4
Cotton	Stalks and straw	4.25	41	2.5
Hard wheat	Straw	1.6	15	1.4
Maize	Stalks	9.1	60	3.6
Maize	Cobs	1.4	50	0.7
Oat	Straw	1.4	15	1.2
Barley	Straw	2.7	15	2.3
Rye	Straw	1.8	15	1.5
Olives	Prunning	1.7	40	1.0

Table B.3
Biomass production (tons) per crop and per zone.

Crop	Zone				SUM
	A	B	C	D	
Pomegranate	195.5	102.3	68.6	35.6	402.0
Cherry trees	81.5	34.1	102.8	213.4	431.8
Vineyards	36.3	103.9	328.9	495.8	964.9
Tobacco	5.2	4.3	22.5	34.0	66.0
Rice	0.0	0.0	0.0	5264.2	5264.2
Sunflower	4.6	13.2	41.8	63.0	122.6
Cotton	830.8	2380.2	7534.5	11,358.3	22,103.8
Hard wheat	4305.9	12,331.4	39,038.7	58,845.5	114,521.5
Maize (stalks)	936.0	2681.7	8489.0	12,797.1	24,903.8
Maize (cobs)	180.0	515.7	1632.5	2461.0	4789.2
Oat	4.2	12.1	38.2	57.5	111.9
Barley	348.5	998.3	3160.2	4764.0	9271.1
Rye	192.3	551.0	1744.3	2629.5	5117.1
Olives	17.7	50.6	160.3	241.7	470.3
SUM	7138.6	19,778.8	62,362.3	99,260.5	188,540.1

Appendix B.

See Tables B1–B9.

Table B.4
Heat production (MJ) using the total available biomass.

Crop	LHV (MJ/kg)	Zone				SUM
		A	B	C	D	
Pomegranate	22	3,871,702.9	2,026,048.3	1,357,473.2	704,221.6	7,959,446.1
Cherry trees	22	1,613,209.6	675,349.4	2,036,209.8	4,225,329.8	8,550,098.6
Vineyards	22	718,104.1	2,057,304.6	6,512,450.7	9,817,489.3	19,105,348.6
Tobacco	16	74,852.9	61,621.1	324,505.6	489,190.7	950,170.2
Rice	15	0.0	0.0	0.0	71,067,166.7	71,067,166.7
Sunflower	17	70,526.9	202,053.4	639,605.2	964,201.9	1,876,387.4
Cotton	18	13,459,051.7	38,558,992.3	122,059,484.0	184,004,107.8	358,081,635.8
Hard wheat	16	62,005,439.9	177,571,880.7	562,156,803.2	847,374,787.1	1,649,108,911.0
Maize (stalks)	16	13,479,067.0	38,616,334.6	122,241,002.4	184,277,746.0	358,614,150.1
Maize (cobs)	18	2,916,144.3	8,354,495.5	26,446,370.7	39,867,781.6	77,584,792.1
Oat	17	64,375.8	184,431.1	583,821.4	880,108.1	1,712,736.5
Barley	17	5,331,546.6	15,274,409.2	48,351,536.0	72,889,717.0	141,847,208.8
Rye	17	2,942,691.6	8,430,551.1	26,687,126.9	40,230,720.5	78,291,090.1
Olives	22	349,989.8	1,002,689.9	3,174,040.8	4,784,851.8	9,311,572.3
SUM	–	106,896,703.2	293,016,161.3	922,570,429.9	1,461,577,419.9	2,784,060,714.4

Table B.5
Electricity production (MJ) using the total available biomass.

Crop	LHV (MJ/kg)	Zone				SUM
		A	B	C	D	
Pomegranate	22	860,378.4	450,233.0	301,660.7	156,493.7	1,768,765.8
Cherry trees	22	358,491.0	150,077.7	452,491.1	938,962.2	1,900,021.9
Vineyards	22	159,578.7	457,178.8	1,447,211.3	2,181,664.3	4,245,633.0
Tobacco	16	16,634.0	13,693.6	72,112.4	108,709.0	211,148.9
Rice	15	0.0	0.0	0.0	15,792,703.7	15,792,703.7
Sunflower	17	15,672.6	44,900.8	142,134.5	214,267.1	416,975.0
Cotton	18	2,990,900.4	8,568,665.0	27,124,329.8	40,889,801.7	79,573,696.8
Hard wheat	16	13,778,986.7	39,460,417.9	124,923,734.1	188,305,508.2	366,468,646.9
Maize (stalks)	16	2,995,348.2	8,581,407.7	27,164,667.2	40,950,610.2	79,692,033.4
Maize (cobs)	18	648,032.1	1,856,554.5	5,876,971.3	8,859,507.0	17,241,064.9
Oat	17	14,305.7	40,984.7	129,738.1	195,579.6	380,608.1
Barley	17	1,184,788.1	3,394,313.2	10,744,785.8	16,197,714.9	31,521,602.0
Rye	17	653,931.5	1,873,455.8	5,930,472.6	8,940,160.1	17,398,020.0
Olives	22	77,775.5	222,820.0	705,342.4	1,063,300.4	2,069,238.3
SUM	-	23,754,822.9	65,114,702.5	205,015,651.1	324,794,982.2	618,680,158.7

Table B.6
Thermal power (MWh) using the total available biomass.

Crop	Zone				SUM
	A	B	C	D	
Pomegranate	1075.5	562.8	377.1	195.6	2211.0
Cherry trees	448.1	187.6	565.6	1173.7	2375.0
Vineyards	199.5	571.5	1809.0	2727.1	5307.0
Tobacco	20.8	17.1	90.1	135.9	263.9
Rice	0.0	0.0	0.0	19,740.9	19,740.9
Sunflower	19.6	56.1	177.7	267.8	521.2
Cotton	3738.6	10,710.8	33,905.4	51,112.3	99,467.1
Hard wheat	17,223.7	49,325.5	156,154.7	235,381.9	458,085.8
Maize (stalks)	3744.2	10,726.8	33,955.8	51,188.3	99,615.0
Maize (cobs)	810.0	2320.7	7346.2	11,074.4	21,551.3
Oat	17.9	51.2	162.2	244.5	475.8
Barley	1481.0	4242.9	13,431.0	20,247.1	39,402.0
Rye	817.4	2341.8	7413.1	11,175.2	21,747.5
Olives	97.2	278.5	881.7	1329.1	2586.5
SUM	29,693.5	81,393.4	256,269.6	405,993.7	773,350.2

Table B.7
Electrical power (MWh) using the total available biomass.

Crop	Zone				SUM
	A	B	C	D	
Pomegranate	239.0	125.1	83.8	43.5	491.3
Cherry trees	99.6	41.7	125.7	260.8	527.8
Vineyards	44.3	127.0	402.0	606.0	1179.3
Tobacco	4.6	3.8	20.0	30.2	58.7
Rice	0.0	0.0	0.0	4386.9	4386.9
Sunflower	4.4	12.5	39.5	59.5	115.8
Cotton	830.8	2380.2	7534.5	11,358.3	22,103.8
Hard wheat	3827.5	10,961.2	34,701.0	52,307.1	101,796.8
Maize (stalks)	832.0	2383.7	7545.7	11,375.2	22,136.7
Maize (cobs)	180.0	515.7	1632.5	2461.0	4789.2
Oat	4.0	11.4	36.0	54.3	105.7
Barley	329.1	942.9	2984.7	4499.4	8756.0
Rye	181.6	520.4	1647.4	2483.4	4832.8
Olives	21.6	61.9	195.9	295.4	574.8
SUM	6598.6	18,087.4	56,948.8	90,220.8	171,855.6

Table B.8
Thermal power (MW) using the total available biomass for 2000 h operation.

Crop	Zone				SUM
	A	B	C	D	
Pomegranate	0.538	0.281	0.189	0.098	1.105
Cherry trees	0.224	0.094	0.283	0.587	1.188
Vineyards	0.100	0.286	0.905	1.364	2.654
Tobacco	0.010	0.009	0.045	0.068	0.132
Rice	0.000	0.000	0.000	9.870	9.870
Sunflower	0.010	0.028	0.089	0.134	0.261
Cotton	1.869	5.355	16.953	25.556	49.734
Hard wheat	8.612	24.663	78.077	117.691	229.043
Maize (stalks)	1.872	5.363	16.978	25.594	49.808
Maize (cobs)	0.405	1.160	3.673	5.537	10.776
Oat	0.009	0.026	0.081	0.122	0.238
Barley	0.740	2.121	6.715	10.124	19.701
Rye	0.409	1.171	3.707	5.588	10.874
Olives	0.049	0.139	0.441	0.665	1.293
SUM	14.847	40.697	128.135	202.997	386.675

Table B.9
Electrical power (MW) using the total available biomass for 7000 h operation.

Crop	Zone				SUM
	A	B	C	D	
Pomegranate	0.034	0.018	0.012	0.006	0.070
Cherry trees	0.014	0.006	0.018	0.037	0.075
Vineyards	0.006	0.018	0.057	0.087	0.168
Tobacco	0.001	0.001	0.003	0.004	0.008
Rice	0.000	0.000	0.000	0.627	0.627
Sunflower	0.001	0.002	0.006	0.009	0.017
Cotton	0.119	0.340	1.076	1.623	3.158
Hard wheat	0.547	1.566	4.957	7.472	14.542
Maize (stalks)	0.119	0.341	1.078	1.625	3.162
Maize (cobs)	0.026	0.074	0.233	0.352	0.684
Oat	0.001	0.002	0.005	0.008	0.015
Barley	0.047	0.135	0.426	0.643	1.251
Rye	0.026	0.074	0.235	0.355	0.690
Olives	0.003	0.009	0.028	0.042	0.082
SUM	0.943	2.584	8.136	12.889	24.551

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